Plasma Treated PP/Nafion® Composite Electrolyte Membranes for Direct Methanol Fuel Cells

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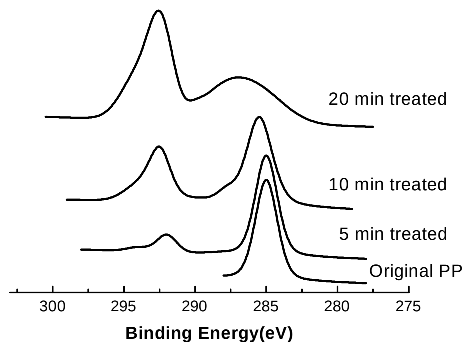
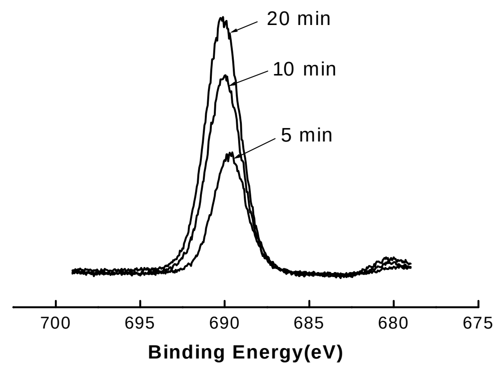
Polymer electrolyte membranes in polymer electrolyte fuel cells (PEFC) are acting as conductors for proton but insulators for electron. Nafion® (Du Pont), XUS (Dow) and Aciplex-S® (Asahi), etc. are well - known polymer electrolyte membranes commercially available for the fabrication of membrane electrode assemblies (MEA) [1,2]. Even though the commercial polymer electrolyte membranes have several advantages over liquid electrolytes, there are some problems to overcome to extend their application - i) high cost, ii) low mechanical strength, and iii) reduction of efficiencies due to methanol crossover for DMFC. Many researches have been conducted to reduce these drawbacks by several ways. Most researches were focused on the synthesis or application of new polymeric materials, but some were on the preparation of composite membranes. Recently, Gore-Textile Associates developed Gore-Select™ composite membranes, but their preparation cost was still high for the practical application. As more economical polymer composite systems were needed, impregnation of Nafion® solution in polypropylene (PP) membrane was ever tried [3]. In this study, PP membranes were modified by plasma to generate the fluorocarbon molecules on membrane surface. By this technique, more sorption of Nafion® solution and improvement of interfacial stability between Nafion® molecules and PP membranes were expected.

Chemical and physical structures of plasma treated membrane surface were characterized using FTIR-ATR, SEM and XPS. After impregnation of Nafion® molecules in membranes, ion conductivity, methanol permeability, and other thermal and sorption properties were also investigated.

Figure 1 shows the XPS spectra of plasma treated PP membranes surface for different times. The longer plasma treatment led to more replacement of carbon atoms with fluorine atoms on the PP membrane surface. The plasma treatment of PP composite membranes induced not only more impregnation of Nafion® molecules, but higher adsorption stability in PP membranes. Fig. 2 (a) and (b) show the cross-sectional morphologies of the neat PP membranes impregnated with Nafion® solution and the plasma treated PP membranes impregnated with Nafion® solution, respectively. The PP composite membranes prepared in this study reduced the methanol crossover and proton conductivity about ten times as much as each of the commercial Nafion® membranes. Also, the higher physical interaction between the membrane surface molecules and Nafion® molecules induced by plasma treatment resulted in much more stable absorption of Nafion® molecules in membranes.

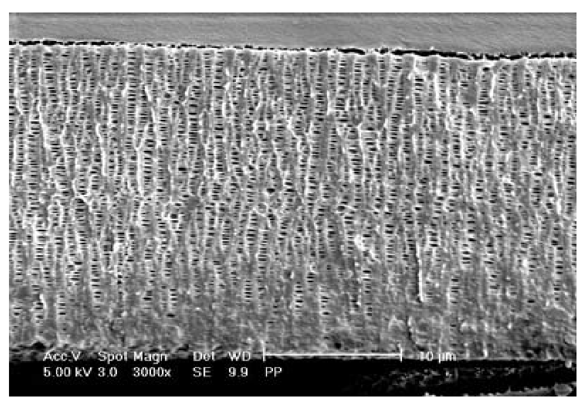


(a)

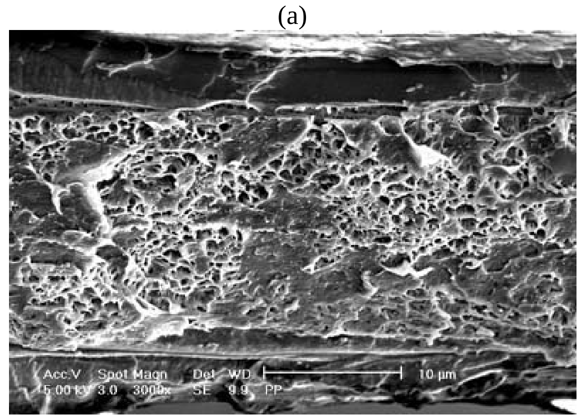


(b)

Fig. 1. XPS spectra of PP membranes treated by plasma for 5, 10, and 20 min: (a) C_{1s} binding energy ; (b) F_{1s} binding energy, respectively.



(a)



(b)

Fig. 2. Cross-sectional SEM photographs of Nafion® impregnated PP membranes: (a) not treated by plasma; (b) treated by plasma.

References

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3. K. M. Nouel and P. S. Fedkiw, *Electrochim. Acta*, **43**, 2381 (1998).